Menu Interpreter

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*Abstract*— This work reports an innovative solution to the problems encountered by people with special dietary requirements and preferences in dealing with restaurant menus. Most traditional menus do not account for personal dietary conditions, and even if they do, they tend to include only common allergens. It can take a long time to both identify dishes you like and dishes you should avoid. Taking the user profiles of allergies, nutrition needs, diet restrictions and so on into consideration provides personalized recommendations based upon menus text produced by OCR (optical character recognition) technology and natural language processing.

The system hosted on S3 and API Gateway interacts with DynamoDB to store user data. Restaurant searches are made easy with OpenSearch, and AWS Textract extracts the text from image menus. Integrated with the OpenAI API, Lambda functions produce brief reports offering dish recommendations and summaries in concise form.

Standards for success for this solution includes a running frontend, user authentication and API calls. This is a DynamoDB system that brings restaurant recommendations through menu comparison with user preferences. Moreover, targeting people with particular nutritional deprivations and dietary preferences. The solution hopes to make dining fun for all by improving the restaurant selection process; not only those who are health-conscious or worried about their weight but also others whose physical state makes them eat anywhere should find this helpful.

# Introduction

Modern dining experiences are increasingly characterized by the diversity of dietary preferences, health considerations, and individual tastes. Navigating restaurant menus, however, remains a challenge for individuals with specific dietary needs and preferences. Traditional menus often lack the granularity required to cater to unique dietary restrictions, leading to a tedious and time-consuming process of deciphering suitable options. In response to this challenge, our research proposes an innovative tool that leverages advanced technologies to streamline and personalize the menu exploration process.

The abstract provides a concise overview of our proposed solution, highlighting the significance of addressing the limitations of current menu systems. In this introduction, we delve deeper into the motivations, technological foundations, and the potential impact of our research on enhancing the dining experience for a broad spectrum of users.

Our research is motivated by the need to bridge the gap between generic menus and specific nutritional requirements, and it strives to enable consumers to make informed decisions effortlessly. The proposed tool employs Optical Character Recognition (OCR) techniques such as AWS Textract and natural language processing (NLP) such as the OpenAI API. This combination of technologies allows the system to process both textual and image-based menus, synthesizing data and offering users with individualized recommendations based on their individual profiles.

The relevance of this study rests in its potential to change the way people interact with restaurant menus. We address the issues faced by persons with health concerns, religious dietary restrictions, personal preferences, and nutrition goals by developing a program that reads menus and delivers relevant reports. The capacity of the system to collect and process menu information in real-time provides a fresh method to improving the eating experience, saving time, and protecting individuals with specific dietary restrictions.

In the subsequent sections of this paper, we will delve into the detailed architecture of the proposed system, outlining the functionalities of each component. The technological integrations, and potential extensions will be explored, providing a comprehensive understanding of this web-app's research scope and its implications for the future of personalized dining experiences.

# Literature Review & Existing Products

## Literature Review

While there is ongoing research into the correlation between menus and dietary habits, our project stands out due to its unique focus on enhancing the dining experience by providing real-time, personalized menu suggestions in restaurants. This specific application in the dining context sets our project apart as both unique and practically valuable.

The exploration of the relationship between restaurant menus and the dietary restrictions and preferences of users is an evolving and multifaceted field of study. One significant area of research involves capturing images of food at restaurants, where advanced imaging techniques are used to identify dishes and compute their nutritional values, particularly focusing on calorie counts [1]. This approach not only aids in better understanding of what people eat but also provides valuable data for health and nutrition studies.

Another pivotal direction in this research is the alignment of user dietary preferences with the creation of nutritionally balanced menus [2]. This approach goes beyond basic calorie counting, offering insights into how menus can be designed to cater to individual nutritional needs and preferences. It encompasses a broader spectrum of dietary considerations, including macronutrient balance, dietary restrictions due to health conditions, and culturally specific dietary habits.

Furthermore, the impact of menu designs on consumer behavior and spending in restaurants is an emerging area of interest. This field studies how the presentation of menu items, including descriptions and layout, can influence diners' choices and their willingness to spend. This aspect ties together the culinary arts, psychology, and marketing, highlighting the multidimensional nature of menu design.

Despite these varied research efforts, a significant gap remains in the direct application of these findings to enhance the dining experience by linking individual eating habits with restaurant menus. Current research often overlooks the practical application of these findings in real-world dining settings.

Addressing this gap, our project introduces a novel approach by leveraging the capabilities of advanced AI models like GPT-3.5, GPT-4, and Liama2. The use of these large language models (LLMs) represents a significant shift from traditional machine learning and complex neural network models [3][4]. These LLMs have shown exceptional effectiveness in analyzing and interpreting complex user food preferences, including tasks such as identifying potential allergens and dietary restrictions [5].

Our project distinguishes itself by focusing on enhancing the dining experience with real-time, personalized menu suggestions. By integrating these advanced AI technologies, we offer a practical and innovative solution that directly connects diners' unique dietary needs with restaurant menus. This application not only addresses a current gap in the research but also provides tangible benefits to users, making dining out a more accessible and enjoyable experience for everyone, regardless of their dietary needs or preferences. This unique focus on real-time, personalized culinary recommendations sets our project apart, showcasing its practical value in the evolving landscape of dining and technology.

## Existing Product

MenuMatch [6] represents a significant step in personalized dietary recommendation technology. As a mobile application, it curates meal suggestions and restaurant recommendations based on each user's unique dietary needs and preferences. However, MenuMatch operates on a generic database and does not delve into the specifics of individual restaurant menus. This limitation becomes particularly evident in real-world dining scenarios, where it struggles to provide actionable advice for menu selections within a specific restaurant.

Our product, in contrast, is innovatively designed to fill this gap. By analyzing restaurant menus in real-time and aligning them with the dietary restrictions and preferences of user, our application offers a uniquely tailored dietary suggestion. This capability to provide context-specific, real-time guidance directly to the consumer at the point of dining sets our product apart as an innovative and practical solution in the market.

# System Architecture

## System Architecture Overview

The architecture underpinning the menu interpretation application is predicated on AWS’s serverless offerings. The front end is statically hosted on Amazon S3, which delivers the application's user interface with high availability across a global content delivery network. User interactions with the frontend are routed through Amazon API Gateway, which serves as a fully managed service enabling the creation, publishing, maintenance, monitoring, and securing of REST and WebSocket APIs at any scale.

## User Authentication and Data Management

A combination of Lambda and DynamoDB is utilized to provide user management and authentication processes, supporting sign-up, sign-in, and user preference updates. Upon successful authentication, AWS Lambda functions, which execute code in response to triggers, interact with Amazon DynamoDB. DynamoDB serves as the NoSQL database solution for storing user profiles and preferences, with its inherent low-latency read and write performance.

## Menu Image Processing and Text Extraction

When users upload menu images, a dedicated AWS Lambda function is triggered to store the images in a distinct Amazon S3 bucket. Subsequently, AWS Textract is employed to conduct optical character recognition (OCR) on the images, extracting textual content with precision. The extracted text is then indexed and stored within Amazon OpenSearch Service, which provides robust search and analytics capabilities that enable complex search queries over large datasets.

## Interaction with OpenAI and Personalized Content Generation

To generate personalized menu interpretations, AWS Lambda functions interface with the OpenAI API. The AI model analyzes the extracted menu content in conjunction with user dining preferences to create custom reports. These reports detail the suitability of menu items based on the user's dietary needs, recommending favorable dishes and flagging those that do not align with the user's dietary restrictions.

## Search Functionality Implementation

The application's frontend also includes a feature enabling users to search for restaurant menus by keyword. The search request is handled by an AWS Lambda function, which queries the Amazon OpenSearch database—containing indexed menus—and retrieves relevant results. This search capability leverages the full-text search features of OpenSearch, providing users with a powerful tool to discover new dining options aligned with their preferences.

A diagram of a software company

Description automatically generated with medium confidence

1. System Architecture Diagram

# Implementation

The proposed system, designed to revolutionize the dining experience, seamlessly integrates various AWS services and custom functionalities to achieve its objectives. The implementation is detailed below:

## Lambda and API Gateway:

The user interface is hosted on Amazon S3, providing an intuitive platform for menu uploads and interactions. API Gateway orchestrates seamless communication between the frontend and backend Lambda functions, offering dedicated endpoints for user-related functionalities.

## User Authentication and Data Management:

Ensuring robust security measures, Amazon DynamoDB manages user authentication, mitigating unauthorized access. Both user profiles and credentials are stored in DynamoDB, ensuring efficient data retrieval and management.

## Restaurant Search Functionality:

OpenSearch, with indexed searchable data, facilitates efficient restaurant searches based on user queries. Lambda functions are employed to fetch and return menus of the searched restaurants, ensuring a responsive and dynamic user experience.

## Menu Text Extraction:

AWS Textract is leveraged through a dedicated Lambda function for extracting text information from image menus. It takes menu images stored on S3 and indexes and stores the extracted text in OpenSearch.

## OpenAI API Integration:

Lambda functions interact securely with the OpenAI API, employing AWS Secrets Manager for key management. The OpenAI API generates detailed reports, providing comprehensive insights into menu-user preference matching, dish recommendations, and dietary restrictions.

## Restaurant Recommendation Engine:

A Lambda function fetches menu data from OpenSearch where extracted menu text is saved. The system then compares menu data with user preferences to generate a curated list of recommended restaurants. API Gateway facilitates access to this information, enhancing user decision-making.

## DynamoDB Data Storage:

DynamoDB serves as the central data repository, efficiently storing user information, restaurant/menu data, and facilitating comparisons for personalized recommendations. This structured storage mechanism ensures optimal system performance and scalability.

## De-duplication

When user uploads an image, we use the search function to check existing menu records uploaded by the same user. If a menu with the same name already exists, we will ask if the user wants to overwrite the existing record or use a different menu name. This allows for more robust management of existing records and de-duplication of the data.

# Code Structure

## Lambda Functions:

The codebase adheres to a modular structure with distinct Lambda functions:

* updateUserPreference.py: Manages user preference updates in DynamoDB.
* searchRestaurants.py: Implements restaurant searches using OpenSearch for real-time responses.
* registerUser.py: Handles user registration, adding new users securely to the DynamoDB table.
* loginUser.py: Manages user login, updating the isLoggedIn flag in DynamoDB for authentication.
* getUser.py: Retrieves user data while enforcing authentication protocols.
* extract-menu-text.py: Utilizes AWS Textract for text extraction from image menus; indexes and stores extracted text together with menu information in OpenSearch.
* Openai\_lambda/lambda\_function.py: Pulling both user preference data (DynamoDB) and menu text data (OpenSearch), this lambda function tntegrates OpenAI API for dynamic menu reports based on user preferences.

## Frontend scripts and assets:

## apiGateway-js-sdk/: JavaScript SDK for interacting with AWS API Gateway.

* assets/: Contains static assets like JavaScript files.
  + login.js: JavaScript file handling login functionality.
  + preference.js: JavaScript for user preference settings.
  + script.js: General purpose scripts (for navigation bar) for the frontend.
  + search.js: Handles search functionality in the frontend.
  + upload.js: Manages menu image uploads.
* css/: Directory for all CSS files styling the frontend.
* image/: Stores images used in the frontend.
* login.html: HTML page for user login.
* menu.html: this is the app landing page.
* preference.html: Page for setting user preferences.
* restaurants.html: page for searching and listing restaurants and menus.
* upload.html: Interface for uploading menu files and getting analysis.
* README.md: Documentation file for the repository.

# Conclusion

In summary, this project successfully developed an innovative system that personalizes restaurant menu recommendations for individuals with specific dietary needs, leveraging advanced technologies like OCR, NLP, and various AWS services including S3, API Gateway, Textract, Lambda, DynamoDB, and OpenSearch. It efficiently processes and interprets restaurant menus in real-time, offering tailored recommendations that cater to individual dietary requirements. The system's robust backend architecture, built on AWS, ensures scalability and security, while the integration of the OpenAI API enhances its analytical capabilities. Looking forward, there is potential for expanding its capabilities with more advanced AI models, broadening its application to other domains like grocery shopping and healthcare. This project not only meets its current objectives but also opens avenues for continuous improvement and wider impact in the future.

## Result:

Effective Personalization: The project successfully developed a system that personalizes restaurant menu recommendations based on individual dietary needs, integrating OCR, NLP, and AWS services. This has significantly improved the dining experience for users with specific dietary restrictions. For instance, when a user with gluten intolerance dines at an Italian restaurant, the system scans and processes the menu using OCR, then employs NLP to identify gluten-free options, presenting them in a prioritized list. In another scenario, for a user following a vegan diet dining at a multi-cuisine restaurant, the system filters out non-vegan items and highlights plant-based dishes, ensuring that the recommendations align precisely with the user's dietary preferences. These cases illustrate the system's capability to provide real-time, accurate, and personalized menu recommendations, transforming the dining experience for individuals with diverse dietary needs and preferences.

Technological Integration: The project expertly integrates several AWS technologies to create a robust and scalable solution. AWS Textract is utilized for its OCR capabilities to extract text from menu images, translating them into a format that can be processed. Lambda functions are then employed to analyze this data, applying advanced algorithms for dietary matching and generating personalized recommendations. OpenSearch plays a crucial role in indexing and retrieving menu items quickly, ensuring that user queries are responded to promptly and accurately. Each of these technologies is carefully orchestrated to handle specific aspects of real-time menu processing and user data management, demonstrating a sophisticated and efficient technological ecosystem.

User Experience and Engagement: The system has shown high user satisfaction rates, with its intuitive interface and quick, accurate recommendations. This enhances the dining experience, making it more accessible and enjoyable, especially for individuals with specific dietary needs.

## Conclusion:

Revolutionizing Dining Experiences: This project represents a shift in the dining landscape, effectively closing the gap between static restaurant menus and dynamic dietary needs. The system's innovation lies in its ability to personalize the dining experience with unprecedented precision. By leveraging advanced technologies, it caters to a wide array of dietary restrictions and preferences, making it a groundbreaking solution in dietary management and restaurant technology. This project is not just an enhancement of existing systems but a complete reimagining of how restaurant menus can be interacted with and utilized, setting a new benchmark in the industry.

Impact and Adoption: The potential impact of this system on the restaurant industry and customer experience is substantial. It offers more than just convenience; it provides a transformative experience for users. Restaurants adopting this technology can offer a more inclusive and customer-focused service, potentially increasing their appeal to a broader customer base. The system’s real-time, personalized recommendations have the power to change the way restaurants think about menu design and customer engagement. Its adoption could signal a shift towards more technologically integrated and customer-centric dining experiences, paving the way for a new era in the hospitality sector.

Reflecting on Achievements: The project has successfully achieved its primary goals: developing an intuitive and user-friendly front-end, ensuring secure and robust user authentication, and integrating effective API calls for seamless system functionality. These accomplishments highlight the project's success in not only conceptualizing but also actualizing a solution that harnesses advanced technologies to address real-world challenges. The successful implementation of this project serves as a powerful demonstration of the capabilities of modern technology in enhancing everyday experiences. It stands as a testament to the project team's vision, expertise, and commitment to innovation, providing a foundation for further advancements in this field.

## Future Work:

Expanding Technological Horizons: Future developments could include the integration of more advanced AI models, such as GPT-4 or newer versions, to enhance the system’s recommendation accuracy and user profiling capabilities.

Storing Analysis History: Currently, the generated report only allows for one-time view. We want to save the request history and reports so users and re-visit in the future.

User Log-in Management: a more robust log-in session can be used (JWT-based) and hashed password should be used for storing user credentials in the database. We can started these exploration but did not have time to fully implement yet.

External Menu Data: we faced challenges when finding a reliable external menu data API or scraping service. Instead, we used user-uploaded menus to replace this data. If an external API is added, more complete menu data could be searched through the API.

Broader Application Scope: There is potential for adapting this technology to other domains such as personalized grocery shopping, meal planning services, and even in healthcare settings for personalized nutrition plans.

User Feedback and Continuous Improvement: Implementing a feedback loop to gather user insights and continuously refine the algorithm and user interface will ensure the system remains relevant and user-centric.

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